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(54) **Air atomising nozzle assembly.**

(57) An air atomising nozzle assembly for electrostatic spray guns is disclosed. The nozzle assembly is made of polyamide-imide («Torlon») plastic parts and includes an air cap having a central bore which surrounds a fluid nozzle tip. The fluid nozzle tip has a nut formed on its forward end to facilitate threading of the rearward end of the nozzle tip into a threaded bore of the gun body. Formed on the front part of the nozzle, either as a part of the nut or a cylindrical surface adjacent the nut, is an accurately machined surface engageable in press fit relationship with a mating accurately machined bore of the air cap. These mating press fit surfaces centre the bore of the air cap relative to the nozzle tip so as to leave an annular, evenly dimensioned air flow passage surrounding the nozzle tip and defined between the nozzle tip and the bore of the air cap. The air cap is retained in a one-piece resilient retaining ring by snapping the air cap into an annular lip of the retaining ring. The retaining ring is then threaded onto the gun body to secure the nozzle assembly onto the gun body.

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AIR ATOMISING NOZZLE ASSEMBLY

This invention relates to electrostatic spray systems and particularly to an improved nozzle assemby for electrostatic spray guns. More specifically, this invention relates to an external air atomizing nozzle assembly for electrostatic spray guns such as that disclosed in United States Patent No. 3,747,850 or United States Patent No. 4,273,293.

In conventional electrostatic spray systems, a fluid coating material such as paint, varnish, lacquer and the like is passed through the barrel of a spray gun, into a fluid nozzle which is threaded at its rear into a counterbore in the forward end of the barrel, and through and out of a small diameter bore in the nozzle tip at the forward end of the nozzle. An air cap surrounds the forward end of the nozzle and includes a central bore surrounding the tip of the nozzle so as to define an annular air passage around the nozzle tip. Air issuing from this annular passage impacts with the stream of material issuing from the material orifice of the nozzle to at least coarsely atomise the material stream. There may be additional openings or ports in the air cap to further atomise or control the material stream as well as a pair of fan-shaping ports located in a pair of opposed horns of the air cap. A trigger operated valve controls the flow of air through the atomising air passage, and a manually adjustable valve controls the amount of air issuing from the horn of the nozzle and thus the degree of "fan" formed by the atomised spray.

In such systems, it is of utmost importance that the annular air passage defined by the wall of the central bore in the air cap and the outside diameter of the fluid nozzle tip be accurately concentric with the material orifice of the nozzle. If this concentricity deviates by as little as one or two one-thousandths of an inch, atomisation of the material becomes non-uniform and the shape of the spray emitted from the gun becomes distorted. Because the fluid tip has in the past usually been supported at its rearward end removed from the nozzle, it has been extremely difficult to obtain the accurate alignment of the nozzle tip in the central bore. This is particularly true when the nozzle assembly is formed of a non-conductive material such as plastic since it is particularly difficult to manufacture plastic parts to the tolerances required to achieve concentricity.

The problem of controlling the atomisation of the fluid material and the shape of the spray emitted from the gun increases as the flow rate of material through the gun decreases. In sum, very small variations in the annular air passage surrounding the fluid nozzle tip have been found to have very drastic effects on the shape of the spray pattern emitted from the gun.

In our United States Patent No. 4,273,293 there is disclosed a solution to the problem of controlling atomisation and the shape of the spray patterns emitted from an electrostatic air spray gun. This solution comprises accurately positioning the

central bore of the air cap around the nozzle tip by machining a plurality of axially aligned holes evenly spaced about the circumference of the bore and having those holes intersect the bore so that the holes define a plurality of uniformly dimensioned, circumferentially spaced ribs between the holes. These ribs are engageable with the peripheral surface of the nozzle tip to align the centre axis of the nozzle concentric with the centre axis of the air cap bore. The difficulty with this solution to the problem is that it is very difficult and expensive to accurately machine the plurality of holes and ribs in the air cap so as to establish this concentricity. Furthermore, the ribs between the holes reduce the air flow rate through the air flow passage such that it is difficult to obtain sufficient air flow for many applications.

Prior to the advent of electrostatic spraying, air spray nozzle assemblies were made of metal which were easily machineable to close tolerances and which resulted in nozzle assemblies having fine spray patterns. Electrostatic spraying dictated that the nozzle assemblies be made from a electrically non-conductive material. One of the earlier known materials chosen and used commercially was a "Bakelite" material which ultimately proved to be unsatisfactory because of its brittleness and the case with which it was broken under production use conditions. Subsequently, and until this invention, the best material for this use has been "Delrin", an acetal resin made by E.I. DuPont DeNemours & Co. Inc. of

Wilmington, Delaware, United States of America. But, "Delrin" is difficult to machine and hold to close dimensional tolerances under production conditions. Additonally, "Delrin" is subject to dimensional change or chemical attack in solvent containing environments so that under spraying conditions, air caps and fluid nozzles change. Consequently, nozzles made from "Delrin" have varying spray patterns, irrespective of the care taken to ensure dimensional uniformity from one nozzle to the next.

It has therefore been a primary objective of this invention to create an electrostatic spray nozzle assembly which is capable of spraying identical spray patterns from one production made nozzle assembly to the next.

Still another objective of this invention has been to provide an electrostatic air spray nozzle assembly which is not subject to the problems described hereinabove and specifically, which is not brittle and thus subject to breakage, is not subject to deterioration by solvents, is not subject to plastic flow during production, and which may be reproduced under production manufacturing conditions.

These objectives have been met by an electrostatic air spray nozzle assembly in accordance with the invention which is made from polyamide-imide resin (commonly identified as "Torlon"). Such air spray nozzles are not brittle and subject to becoming easily broken, are not subject to plastic flow during

machining, and are resistant to solvent attack. Consequently, such "Torlon" air spray plastic nozzles may be made to close tolerances and specifications under production conditions and will spray substantially identical spray patterns from one nozzle to the next.

The invention will now be further described by way of example with reference to the accompanying drawings in which:

Figure 1 is a side elevational view showing in phantom a manually operated electrostatic air spray gun incorporating the nozzle assembly of this invention (shown in solid),

Figure 2 is an exploded perspective view with part broken away of one embodiment of nozzle assembly of this invention

Figure 3A is a partial exploded perspective view of a prior art nozzle,

Figure 3B is an end view of the prior art nozzle shown in Figure 3A,

Figure 4A is a cross sectional view of a second prior art nozzle,

Figure 4B is an end elevational view of the prior art nozzle shown in Figure 4A,

Figure 5 is an axial cross sectional view of the embodiment nozzle assembly of this invention,

Figure 6 is an end elevational view taken on line 6-6 of Figure 5,

Figure 7 is a cross sectional view taken on line 7-7 of Figure 5.

The gun 10 illustrated in Figure 1 of the drawings is an air operated electrostatic spray gun which relies upon the impact of an air stream with liquid stream to effect atomisation of the liquid stream. While the invention is described as applied to an air gun, it should be understood, though, that the invention is equally applicable to all electrostatic spray guns or to spray systems in general.

The gun 10 shown in phanton in Figure 1 is described in detail in our United States Patent No. 3,747,850. The gun is generally described here only for purposes of illustrating the application of the present invention.

The gun 10 comprises an electrically conductive metal handle assembly 11, an electrically insulative barrel assembly 12, and an insulative nozzle assembly 13. Paint or other spray material which may be in the nature of a coating, varnish, or lacquer (referred to in regard to this invention generically as paint) is supplied to the gun from an external reservoir or tank (not shown) through a material passage 14. A high voltage source of electrical energy is supplied to the gun by a cable 15 from an external electrical power pack (not shown).

The handle assembly 11 is generally made from a metal casting and incudes an air inlet 16, a trigger actuated internal air flow control valve 17 and a trigger 18 for controlling the flow of air through the valve 17. There is also an adjustable air valve 20 in the gun handle for controlling the shape or "fan" of the

spray emitted from the gun.

The air inlet 16 opens into a generally vertical air passage in the handle 11 which communicates through the air flow control valve 17 with a pair of internal passages 22, 24 passing through the barrel 12 of the gun and terminating at the forward end of the barrel 12 (Figure 2). The passage 22 provides atomising air while passage 24 provides the fan-shaping air. The flow of air through passages 22, 24 is controlled by the trigger operated air control valve 17 while the flow of fan air through the passage 24 is further controlled by the fan control valve 20.

Referring now to Figures 2 and 5, the nozzle assembly 13 is made from an electrically non-conductive material. It comprises a nozzle 26 which is threaded at its rear 28 into a counterbore 30 in the forward end of the barrel 12. Nozzle 26 has six circumferentially spaced axial passages 32 which open into the rear of the counterbore 30 which in turn communicate with the air passage 22 such that atomising air passing through the passage 22 may enter and pass through the axial passages 32 in the nozzle and into an internal chamber 33 surrounding the forward end 34 of the nozzle 26. The nozzle 26 also has a central axial passage 35 communicating with a material flow passage 36 in the barrel 12 for supply of liquid or fluid via the passage 14 (Figure 1) from the tank or reservoir.

The forward end 34 of the nozzle is generally tapered and terminates in a nozzle tip 38 having a small diameter orifice 40 through which the coating

material is emitted. Immediately rearward of the tapered section 34 of the nozzle, a hexagonal nut 60 is formed on the periphery of the nozzle. This nut facilitates threading of the threaded rear 28 of the nozzle into the threaded counterbore 30 of the gun barrel 12. With reference to Figures 2 and 7, it will be seen that the flats 61 of this nut 60 have their intersecting corners rounded or radiused as indicated at 62. As explained more fully hereinafter, these radiused surfaces 62 may function as a press fit surface on the front of the nozzle 26 engageable with a press fit internal diameter surface of the air cap. As an alternative to the rounded corners 62 of the nut functioning as a press fit surface on the front of the nozzle engageable with a press fit internal diameter surface of the air cap 50, a cylindrical section 63 of the nozzle of the same radius R as the rounded corners 67 may serve the same function or act to supplement the same press fit function.

A material ionising electrode or antenna 42 is mounted on the centre axis of the nozzle and is held in place in the passage 35 by means of a non-conductive holder 44 (Figure 7). Electrical power is supplied to the electrode 42 which protrudes from the orifice 40 of the nozzle tip 38. This power is supplied generally from the electrical power pack which is connected to the gun via a cable 15 which is connected to the electrode 42 via an insulated cable 46 and spring 48.

The air cap 50 surrounds the forward end 34 of the nozzle 26. It includes a central bore 52 through

which the nozzle tip 38 extends, a pair of fan control ports 54, one located on either side of the bore 52, two pairs of recessed fine atomising ports 56, and a pair of ports 58 in each air horn 59. Referring now in addition to Figures 5 and 6 it will be seen that the surface of the central bore 52 is spaced from the internal surface of the nozzle tip 38 such that an annular air flow passage 64 is defined therebetween. This annular air passage 64 opens into the internal air chamber 33 such that air flow into the chamber 33 exits through the annular passage 64.

Extending inwardly into the air chamber 33 of the air cap 50, there is a flange 65. This flange has an internal diameter D the same as or slightly smaller than the external diameter of the cylindrical section 63 of the nozzle and between the rounded corners 62 of the nut section 60 of the nozzle such that when assembled, the flange 65 is press fit onto the nut section 60 and/or the cylindrical section 63 of the nozzle 26. This press fit enables this air cap 50 to be concentrically mounted onto the nozzle with the axis of the air cap bore 52 nearly perfectly concentric with the axis of the nozzle 26 and nozzle orifice 46. The press fit surfaces thus align the nozzle such that the centre axis of the material orifice 40 is on the centre axis of the central bore 52. The co-action of the fluid tip nozzle with the air cap thus provides an annular air flow passage 64 uniformly spaced around the fluid tip nozzle thereby producing a uniform atomising air flow pattern.

This co-action may be further understood and appreciated by referring to Figures 3A and 3B wherein a prior art nozzle assembly is illustrated. Referring first to Figure 3A, in the prior art, the nozzle end 70 of the fluid tip 72 extends through a central bore 74 in the air cap 76 which has a diameter greater than the outside diameter of the nozzle 70 to form an annular air passage around the nozzle. However, in the prior art, the fluid tip 72 is supported at points removed from the nozzle end 70 and because of inaccuracies in manufacture and dimensional instability, it is clearly not aligned in the central bore to provide a uniform annular air passage. Rather, the misalignment of the nozzle in the central bore, as illustrated in Figure 3B results in a lack of concentricity of the air passage 74 about the nozzle and therefore non-uniform atomisation of the material exiting the nozzle. As may be best seen in Figure 6, the nozzle assembly of the present invention by virtue of the cooperation of the air cap 50 with the fluid tip nozzle 38 provides uniformly dimensioned air flow of passage 64 around the nozzle.

Still another prior art assembly is illustrated in Figures 4A and 4B. In this assembly a plurality of circumferentially spaced holes 80 whose axes are aligned with the axis of the central bore 52 are machined in the air cap 50. These holes 80 intersect the circumference of the central bore 52 so as to define a series of circumferentially spaced gas flow passages with spaced radially extending ribs 84

therebetween. The nozzle portion of the fluid tip 26 extends through the central bore 52 and the ribs 84 engage its outside diameter. In this prior art structure, the ribs 84 align the nozzle such that the centre axis of the fluid orifice 40 is on the centre axis of the central bore 52. The difficulty of this prior art structure is that the holes 80 are extremely difficult an expensive to machine and the ribs 84 partially obstruct the flow of air from the chamber 33 prior to engagement with the fluid stream emitted from the orifice 40.

The nozzle assembly of this application with its press fit surfaces on the outside diameter of the front of the nozzle 26 and inside diameter on the air cap 50 for effecting concentricity of the nozzle tip and air cap 50 and thus a uniform concentric air flow passage 64 about the nozzle tip 38, is less expensive to manufacture, maintains better concentricity of the assembled parts when produced on a production basis, and does not partially obstruct the air flow passage surrounding the nozzle tip.

The air cap 50 is mounted to the gun 10 by means of an annular retaining ring 66. The retaining ring 66 is also made from an electrically non-conductive plastic material. It is threaded over a threaded section of the barrel 12 at one end and at its other end has an annular lip 67. The retaining ring 66 although rigid is sufficiently flexible at the lip 69 to permit the air cap 50 to be snapped into position with the lip 67 engaging a ring 68 on the outside

surface of the air cap 50 such that the air cap is securely retained and sealed against escape of air to the atmosphere.

The nozzle 26 and air cap 50 components of this nozzle assembly 13 are made from a polyamide-imide thermoplastic resin which is available commercially under the name "Torlon" from Amoco Chemical Corporation, 200 East Randolph Drive, Chicago, Illinois 60601. The chemistry and properties of polyamide-imide are discussed at page 42 of the "Modern Plastics Encyclopaedia 1981-82" published by McGraw-Hill, Inc., 1221 Avenue of Americas, New York 10020. The disclosure of this portion of the Modern Plastics Encyclopaedia is hereby incorporated herein by reference. Further various grades of the material "Torlon" are discussed in the publication entitled "Torlon® Technical Data & Applications Information" (Publication No. 1117-7.5M-480) published by Amoco Chemicals Corporation, Torlon Sales Group, 200 East Randolph Drive, Chicago, Illinois 60601. The disclosure of the Amoco Publication No 1117-7.5M-480 is hereby incorporated herein by reference. Finally, polyamide-imid resin is discussed in an article entitled "Processing Exotic Thermoplastics" at page 57 in the May, 1980 issue of "Plastics Technology". The article entitled "Processing Exotic Thermoplastics" is hereby incorporated herein by reference. The retainer ring 66 may also be made from this material, although the dimensions of the retainer ring are not critical so that another plastic material may be used for this part.

The advantage of manufacturing these components of this polyamide-imide resin is that the material is dimensionally stable and not as susceptible to all the problems of materials previously used for this purpose. It has impirically been noted that "Torlon" is not subject to chemical attack from solvent and meets all mechanical standards including not being subject to plastic flow during machining. Consequently, these components may be manufactured to close tolerances and specifications so that the liquid and air flow from the nozzle assembly may be closely controlled as to flow rate, direction, pattern, and degree of atomisation. Prior to this invention, such control was not reproducible on production made nozzle assemblies.

Although the invention has been described in terms of a single preferred embodiment, those skilled in the art will recognise that other forms may be adopted within the scope of the invention. Moreover, those skilled in the art will appreciate that although the invention has been described in terms of electrostatic spraying, it is equally applicable to spray apparatus in general.

The invention has been described as being manufactured from pure or substantially pure polyamide-imide resin. It is within the scope of this invention though to manufacture the nozzle and air cap of this invention of a filled polyamide-imide resin containing a filler material.

CLAIMS

1. A nozzle assembly for use in a system for the coating of articles with a liquid coating material supplied from a pressurised source wherein said liquid coating material is emitted from a coating material spray device in the form of an atomised spray, the nozzle assembly comprising: a spray coating nozzle being constructed of an electrically non-conductive polyamide-imide plastic material, said nozzle being adapted to be connected at its rear end to a spay device so as to connect a flow passage of said nozzle with a liquid conduit of the spray device, said nozzle having a nozzle tip portion through which said liquid coating material is emitted in a central stream.

2. A nozzle assembly for use in a system for the coating of articles with a liquid coating material supplied from a pressurised bulk coating source wherein said liquid coating material is emitted from a coating material spray device in the form of an atomised spray produced by impacting a central stream of liquid coating material under pressure with a pressurised gas stream encircling said central liquid stream and wherein the articles to be coated are spaced from said spray device, the nozzle assembly comprising: a spray coating nozzle and an air cap,the nozzle and/or air cap being constructed of an electrically non-conductive polyamide-imide plastic material, the nozzle being adapted to be connected at its rear end to a spray device so as to connect a flow passage of the nozzle with a liquid conduit of the spray device, the nozzle

having a nozzle tip portion through which liquid coating material may be emitted in a central stream, the air cap having an interior bore adapted to be connected to a source of atomising gas, and at least one aperture proximate the nozzle tip and located at least in part in the air cap through which atomising gas is emitted for impinging and atomising the central stream of liquid coating material emitted from the nozzle tip portion of the nozzle.

3. A nozzle assembly as claimed in Claim 1 or 2 in which the polyamide-imide plastic material contains less than twenty-five percent of non-plastic filler material.

4. A nozzle assembly as claimed in any preceding claim in which the air cap is positionably located relative to the nozzle by a press fit engagement of an internal diameter portion of the air cap with an outside diameter portion of the nozzle so as to positively align the centre axis of the nozzle tip on the axis of the air cap bore surface to provide uniform atomising gas flow around the nozzle tip for producing a finely atomised uniform spray pattern of the coating material emitted from the nozzle tip.

5. A nozzle assembly as claimed in Claim 4 in which the nozzle has a nut formed on its forward end, said press fit outside diameter portion of said nozzle, being at least partially located on the nut.

6. A nozzle assembly as claimed in Claim 4 in which the nozzle has a cylindrical portion formed on its forward end, said press fit outside diameter portion

of said nozzle, being at least partially formed on the cylindrical portion of the nozzle.

7. A nozzle assembly as claimed in Claim 4 wherein the forward end of the nozzle tip protrudes forwardly of the outer surface of the air cap.

8. A nozzle assembly as claimed in any of Claims 2 to 7 wherein the air cap includes fan-shaping ports adapted to be placed in communication with a source of atomizing gas, the fan-shaping ports being sealed from the atomising gas annular orifice by mating surfaces of the air cap and the nozzle, means being provided, protruding from the nozzle tip for charging said material.

9. A nozzle assembly as claimed in any of the preceding claims in which the nozzle is adapted to be threaded at its rear end into a threaded section of the spray device.

10. A nozzle assembly as claimed in any of the preceding claims in which the air cap is adapted to be supported upon the spray device by a retaining ring, said retaining ring being adapted to be threaded onto the forward end of the spray device, said retaining ring having an inwardly extending flange snap-fit over an outwardly extending flange of said air cap.

11. A nozzle assembly as claimed in any of Claims 2 to 10 wherein the orifice or aperture for atomising air surrounds the nozzle tip and is located at least in part in the air cap through which atomising gas is emitted.

12. A nozzle assembly as claimed in Claim 11 in which the accurately dimensioned orifice is an annular orifice surrounding the nozzle tip and defined by the exterior surface of the nozzle tip and an interior bore surface of the air cap.

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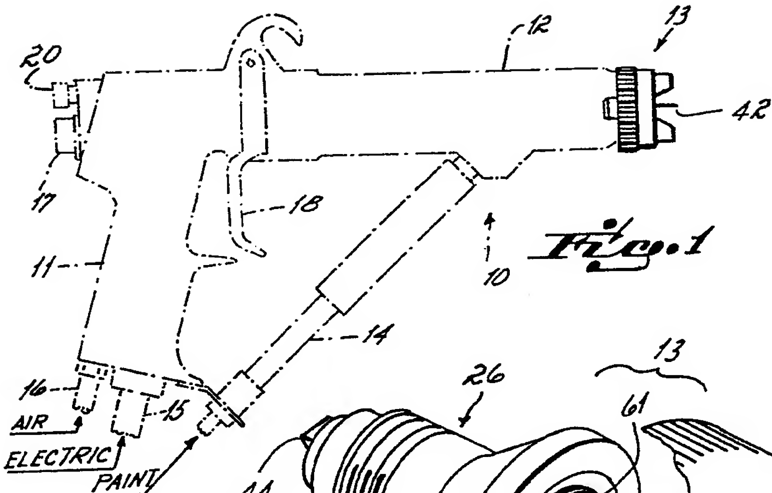


Fig. 1

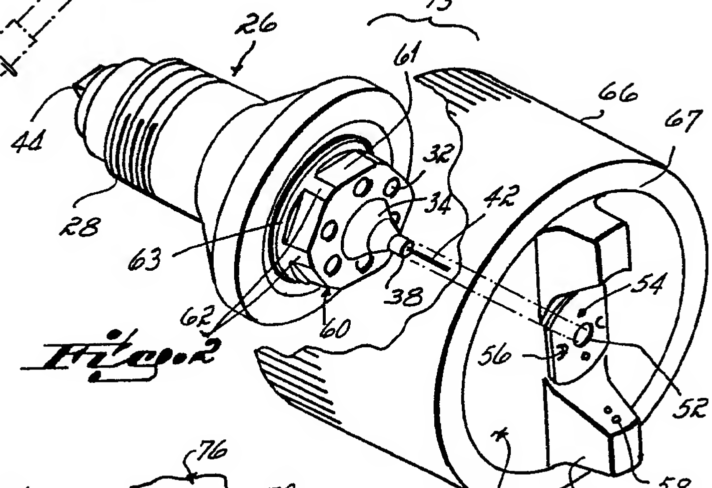
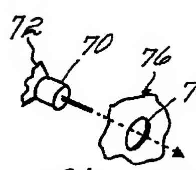


Fig. 2



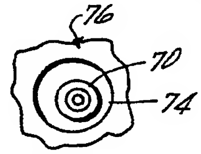
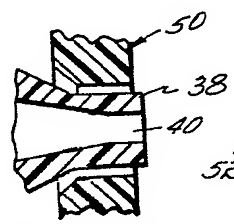


Fig. 3A Fig. 3B

PRIOR ART



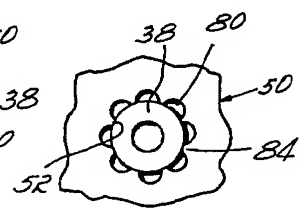


Fig. 4A Fig. 4B

PRIOR ART

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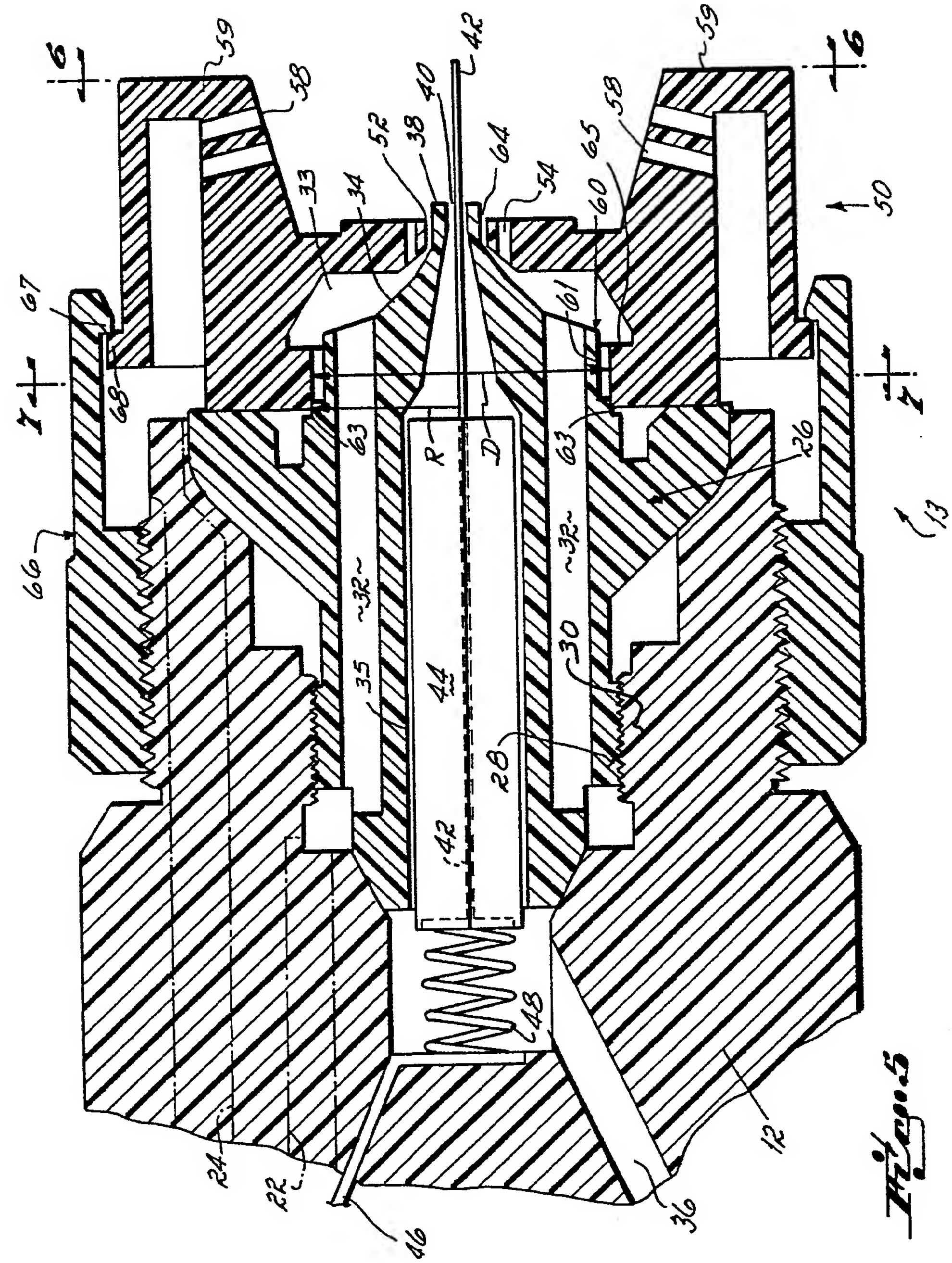

Fig. 5

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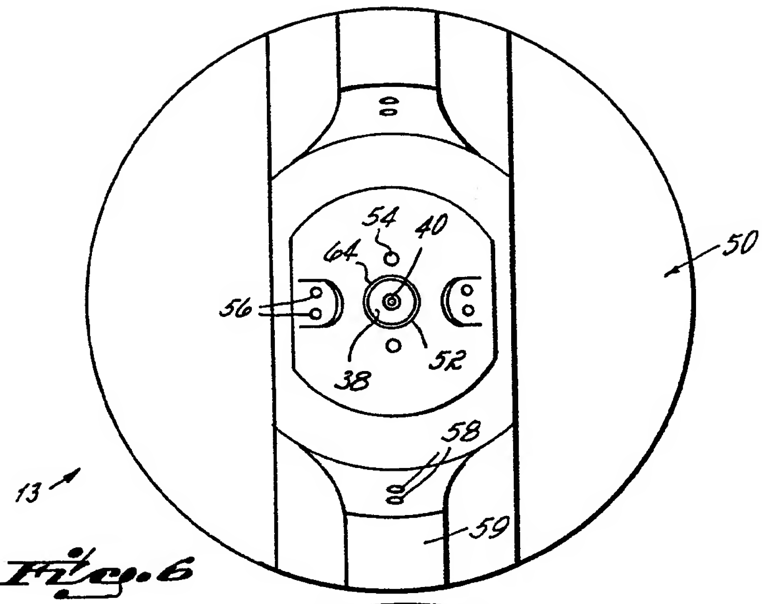

Fig. 6

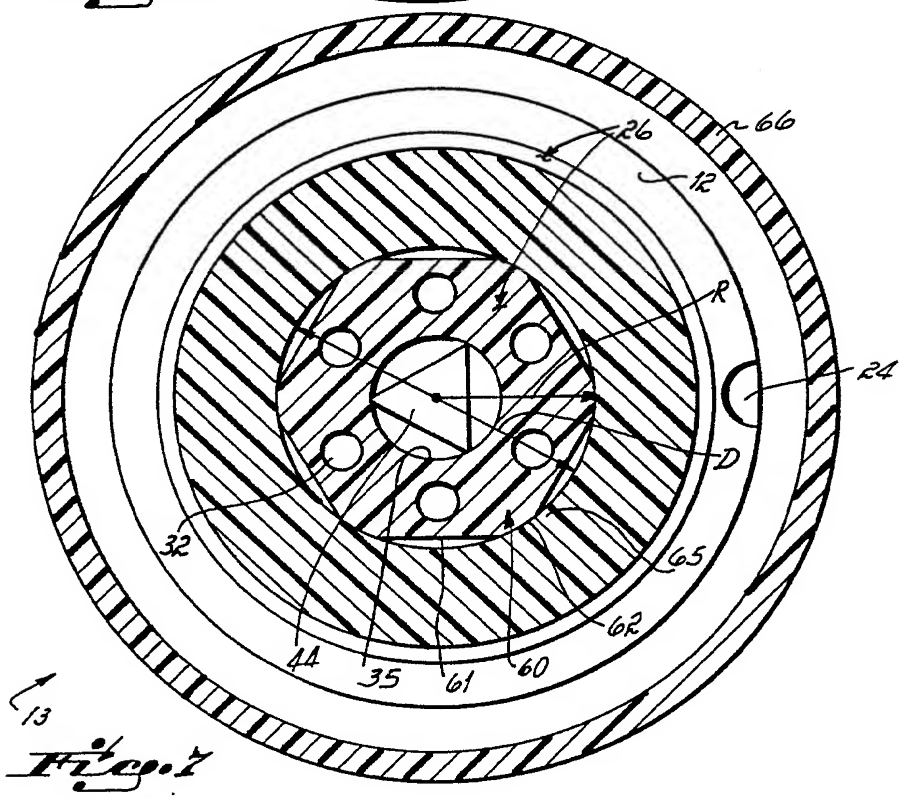

Fig. 7